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DEVELOPMENT SPECIFICATIONS

FOR THE RT-21

3 June 1958

DEVELOPMENT SPECIFICATIONS FOR THE RT-21

1. GENERAL

1.1. Purpose of this Specification

This specification stipulates the performance requirements of the [redacted] RT-21, and presents design characteristics which will guide the development of prototype models of the equipment.

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1.2. Equipment Description

The RT-21 Transmitter shall be a lightweight, miniaturized unit whose design anticipates the use of such components as miniaturized servo motors, teflon or barium titanate dielectric tuning capacitors and full transistorization. The transmitter shall have a self contained hand key for manual keying and shall be capable of keying at a speed of 300 words per minute when used with an external keyer. The power supply will operate from a 12 VDC source or from an accessory AC Power Supply operating from voltages and frequencies enumerated within this Specification.

1.2.1. Design Objectives

Design objectives of the RT-21 Transmitter development include ultra-miniaturization, extreme ruggedness, complete waterproofing and semi-automatic tuning for simplicity of operation.

1.2.2. Equipment Size

[redacted]
[redacted] The maximum volume shall not exceed 27 cubic inches (approximate dimensions, 6" x 3" x 1.5") and not weigh more than two pounds. A maximum effort will be made to reduce further the weight and size.

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2. QUALITY OF DESIGN AND FABRICATION

The electrical and mechanical design of the RT-21 shall be directed toward the development of a miniaturized quality product reflecting the highest possible degree of equipment reliability when exposed to the normally rough handling encountered during field usage.

2.1. JAN Specifications

The contractor shall utilize components, materials, and fabrication procedures meeting JAN Specifications of the issue in effect on the date of initiation of the contract.

2.1.1. JAN Specification Waiver

To accomplish the desired degree of miniaturization, the contractor may deem it necessary to utilize other than components, materials

and fabrication procedures meeting JAN Specifications. In such instances, specific waivers may be authorized by the Government, but only after review by Government engineers and prior to the submission of any prototype models.

2.1.2. Non-Fungus Nutrient Materials

All materials which are used in the RT-21 are to be non-nutrient to fungi. If it is determined that non-nutrient materials are not available and that other materials must be used, a waiver may be obtained as in Section 2.1.1. Any nutrient material shall be treated by a suitable fungi-resistant compound after machining or other work, but prior to installation in any unit of the RT-21.

2.2. Temperature Extremes

2.2.1. Operating Temperature

The design considerations of the RT-21 shall be such as to preclude malfunctioning of the equipment (exclusive of the battery) when exposed to operating temperatures of +50°C to -40°C.

2.2.2. Storage Temperature

The equipment, less batteries, shall be capable of being stored in temperatures within the range of +60°C to -60°C without injurious effect.

3. ELECTRICAL DESIGN CHARACTERISTICS

3.1. General

It is not the intent of the Government to restrict the design ingenuity of the contractor, except in certain circumstances, wherein the Government may specify preferred circuits.

3.2. Normal Operating Mode

The normal operating mode shall be such that all components will draw operating power from either of the two power supplies. The change in operation of the system from battery power to AC mains power, or from AC mains power to battery, shall be such that the simple exchange of the power supply, properly connected, is the only action required.

3.3. Transmitter

The RT-21 shall be a crystal controlled transmitter covering the frequency range of 3 to 30 mc in not more than 3 bands. It shall be possible to key the RT-21 at speeds of 25 words per minute (Morse) and at keying speeds of up to 300 words per minute (Morse) with accessory keying equipment. The transmitter shall operate in A-1 type emission and anticipates a radiated power output of 10 watts. A fully transistorized transmitter is desired for equipment reliability. The tank tuning and antenna loading shall be automatic and, as presently envisioned, accomplished with a servo-motor

system. A "press-to-tune" control would activate the servo motor system and tune the tank and antenna coupling network. Band changing would be accomplished manually.

3.3.1. Crystal Control

The frequency of emission shall be determined by means of a crystal whose fundamental frequency may range from 3 mc to 15 mc or a VFO whose output is between 3 - 10 mc. The RT-21 will use the Armed Services Crystal Unit CR-18/U and Holder HC-6/U.

3.3.1.1. Oscillator Circuitry

The RT-21 will use an untuned transistor oscillator to simplify tuning and the stability shall be determined by the crystal or VFO which determines its frequency. The oscillator shall exhibit no evidence of crystal over-mode oscillation. The oscillator input capacity for crystal correlation shall be 32 micromicrofarads ± 2 micromicrofarads. The oscillator shall have provisions for an external VFO connection.

3.3.2. Transmitter Keying

3.3.2.1. Hand Keying

A self-contained key shall be incorporated for Morse transmissions at manual speeds. When using the hand key, the electronic circuits shall be such that a steady, unmodulated carrier is radiated during the period that the hand key is depressed and no signal is generated when the hand key is up.

3.3.2.2. External Keying Provision

An external keying provision shall be made for keying with accessory automatic keyer at speeds up to 300 wpm (Morse). The maximum operating range with high speed keying will necessarily be less than that obtainable with slow speed keying due to increased bandwidth requirements and resultant reduction in receiver signal to noise ratio.

3.3.2.3. The envelope of the RT-21 keyed wave shall possess rounded corners on the leading and trailing edges and shall have no sharp peaks or abrupt transients.

3.3.2.4. Receiving Antenna Connection

Provisions shall be made for connecting the transmitting antenna to a receiver antenna terminal when the RT-21 key is up. In the key-down position, the antenna shall be reconnected to the transmitter and the receiver antenna terminal will be grounded. This procedure will allow break-in operation during manual keying rates up to 25 words per minute. Break-in operation is not required during high speed transmission.

3.3.3. Antenna Circuits

The output circuit of the RT-21 should be capable of matching any antenna whose impedance falls within a circle described by the following limits: Resistance - 25 to 1300 ohms, Reactance - $+j$ 1000 ohms to $-j$ 1000 ohms.

3.3.3.1. Antenna Coupling and Loading

The RT-21 shall possess a system of antenna loading that will permit maximum power transfer of R.F. energy into the antenna over the entire frequency range. A pi network, or a modified pi network may be used. An R.F. indicator will be used to indicate correct loading of the antenna.

3.3.4. Power Output

The RT-21 anticipates an R.F. power output of 10 watts, when operated over the frequency range of 3 to 30 mc and into an antenna whose impedance may vary as defined in Section 3.3.3.

3.3.5. Interference Elimination

Elimination of interference in the 15 kc to 220 mc frequency spectrum shall be a prime consideration in the design of the RT-21 Transmitter. No spurious radiation shall be generated other than those enumerated in the following sub-sections.

3.3.5.1. Harmonic Radiation

Second harmonic radiation shall be down not less than 35 decibels, third harmonic radiation shall be down not less than 45 decibels and higher order harmonics shall be down not less than 80 decibels from the fundamental.

3.3.5.2. Spurious Radiation

No spurious radiation, other than the harmonics listed in Section 3.3.5.1. shall be generated. The generation of any R.F. power with the crystal removed from its socket or with the external VFO disconnected shall not be permitted.

3.3.5.3. Key Clicks

The output of the RT-21 shall exhibit no evidence of key clicks.

3.3.5.4. Radiated and Conducted Interference Elimination

Radiated and conducted interference elimination shall be a prime consideration in RT-21 design between the frequency limits of 15 kc and 220 mc. The suppression of this interference shall meet the requirements of MIL-I-16910A (SHIPS).

3.4. Power Supply

Transistor switching of the primary voltage shall be used instead of the customary vibrator. The power converter shall operate from 12 VDC plus or minus 1.5 VDC. Suppression of electrical and mechanical noise from this unit shall be a consideration in its design.

3.4.1. Electrical Noise

The radiated and conducted electrical noise of the RT-21 power supply shall conform to Section 3.3.5.4.

3.4.2. Mechanical Noise

Mechanical noise generated by the power supply when the unit is operating at 12 volts under full load shall not exceed 10 decibels above ambient when measured at a distance of six feet in a sound-proof room.

3.4.3. AC Power Supply

The AC Power Supply shall be so designed that satisfactory operation may be obtained over a wide range of input voltages and frequencies. The voltage range shall be 270 to 70 volts, as indicated: OFF, 270, 230, 200, 190, 150, 120, 95, 70 with a line frequency range of 50 to 60 cycles. A selector switch and suitable indicating device shall be provided which will enable the operator to match closely the input of the unit to any one of a number of line voltages.

3.4.4. Cables

A Power Cord five feet long will be used to connect the AC power supply to the AC mains. This cord will be permanently attached to the power unit.

4. MECHANICAL DESIGN CHARACTERISTICS

4.1. Carrying Case

There shall be no carrying case designed specifically for this system, but the basic system design and configuration will be directed toward the end that it may be housed and carried in an The approximate dimensions of the transmitter shall be 6" long x 3" wide x 1.5" deep. A maximum effort will be made to reduce further the weight and size.

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4.2. Case Construction

The contractor shall determine the type of case most suited for the equipment, and the use of plastic may be considered, but approval for its use must be authorized prior to the submission of any prototype models.

4.3.

Controls

All controls shall be designed and arranged to minimize operator error in usage and adjustment. Such controls shall lend themselves to fingertip operation. Furthermore, an absolute minimum number of controls necessary for semi-automatic tuning is desired. Ganging of controls or other circuit functions is to be utilized where feasible. The number and position of all controls shall be approved by the contracting organization prior to determination of final design.

4.3.1.

Marking

All operating controls and terminals shall be suitable, and clearly identified as to function. The band switch shall be clearly marked with the frequency limits of each band for easy operator identification. Symbols, rather than English abbreviations, may be employed where practicable. Information relative to such symbols will be supplied by the contracting organization.

RT-21 DEVELOPMENT TEST SPECIFICATIONS

1. GENERAL

This test specification shall be part of the Development Specifications for the RT-21 Communication Transmitter.

1.1. Purpose of this Specification

This specification outlines the test procedure to be conducted on completed prototypes. Necessary test equipment is itemized, test methods are described, and the test requirements are presented.

1.2. Submittal of Test Data

Test data shall be submitted simultaneously with the delivery of prototype models.

1.3. Test Equipment

The following test equipment is necessary to conduct prototype tests:

1.3.1. Secondary Frequency Standard

Military BC-221 or equivalent.

1.3.2. Wide Band Oscilloscope

Tektronix Type 511-AD or equivalent.

1.3.3. RF Milliammeter

Any type calibrated to within 2% accuracy at full scale.

1.3.4. Non-Inductive R.F. Dummy Loads

Any type having values of 50, 75, 150, 300, 600 and 1200 ohms.

1.3.5. Field Intensity Meter

a) Stoddart Model NM-20-A (150 kc - 25 mc) or equivalent.

b) Stoddart Model NM-30-A (20 - 220 mc) or equivalent.

1.3.6. Communications Receiver

Any type(s) capable of receiving AM and CW signals in the range of from 3 to 220 mc.

1.3.7. Crystal Correlation Meter

This item will be provided as Government Furnished Equipment.

2. SUPPLY VOLTAGES

These specifications require that the AC voltages applied to the RT-21 power supply fall within 2% of the rated input tap. When a battery source is used, a terminal voltage of 12 VDC shall be maintained under full load.

3. TESTS

3.1. Frequency Test Points

RT-21 tests, unless otherwise specified, shall be made at the low end, center, and the high end of each band, except that if a single band transmitter is designed tests shall be made at 3, 6, 12, 18, 24, and 30 mc.

3.2. Temperature Extremes

3.2.1. Low Extreme Temperature Test

Method of Test:

- a. The complete equipment, less the battery, shall remain unenergized in a temperature chamber for a period of 24 hours at -40°C .
- b. A battery source, whose temperature is at normal room level shall be connected to the transmitter.
- c. The transmitter shall be adjusted for operation at the high frequency end of each band and connected to a 300 ohm dummy antenna.
- d. The system shall be energized and allowed to warm for a period not to exceed five minutes with no keying.

Requirements:

- a. The system shall operate without malfunction of any of the components.
- b. The measured power output shall not be less than 10 watts.

3.2.1.1. Low Extreme with the AC Power Supply

Repeat the test of Section 3.2.1. using the external AC Power Supply.

- a. The line voltage will be matched to within $\pm 2\%$ of the rated input tap of the power supply in service.

Requirements:

The system shall operate at its rated output power without malfunction of any of the components.

3.2.1.2. High Extreme Test

Method Of Test:

- a. The entire equipment shall be soaked for a period of 24 hours at 50°C.
- b. The test conditions of Section 3.2.1. (c) and (d) shall apply, except that the unit must remain energized for 30 minutes.

Requirement:

The system shall operate at its rated output power without malfunction of any of the components.

3.2.1.3. High Extreme with AC Power Supply

Repeat the test of Section 3.2.1.2. using the AC Power Supply.

- a. The line voltage will be matched to within $\pm 2\%$ of the rated input tap of the power supply in service.

Requirement:

The system shall operate at its rated output power without malfunction of any of the components.

3.2.2. Storage Temperature

3.2.2.1. Low Extreme

Method of Test:

- a. The entire equipment, less batteries, shall be soaked for a period of 24 hours at -60°C.
- b. The equipment shall be returned to normal room temperature of not less than 20°C, nor more than 25°C, for a period of four hours.
- c. The test conditions of Section 3.2.1. (c) and (d) shall apply.

Requirement:

~~The system shall operate~~ at its rated output power without malfunction of any of the components.

3.2.2.2. High Extreme

Method of Test:

- a. The entire equipment shall be soaked for a period of 24 hours at +60°C.
- b. All conditions of Section 3.2.2.1. (b) and (c) shall apply.

Requirement:

The system shall operate at its rated output power without malfunction of any of the components.

3.3. Operating Characteristics

3.3.1. Power Output

Method of Test:

- a. The transmitter shall be set to the frequencies of Section 3.1.
- b. The transmitter shall be loaded into the appropriate load resistors in series with an R.F. milliammeter or in parallel with an R.F. voltmeter.
- c. Tests shall be conducted using the following dummy antenna impedances: 50, 75, 150, 300, 600 and 1200 ohm non-inductive dummy load antennas.

Requirement:

The transmitter shall deliver not less than 10 watts over its entire operating range.

3.3.1.1. Power Output

Method of Test:

- a. Identical to that required by Section 3.3.1. above, except that the antenna impedance shall fall within a circle described by the following limits: Resistance, 25 to 1300 ohms, Reactance, +j 1000 ohms to -j 1000 ohms.

Requirement:

The transmitter shall deliver not less than 10 watts over the entire operating range.

3.3.2. Keying Characteristics

3.3.2.1. Hand Keying

Method of Test:

- a. The transmitter shall be loaded into a 300 ohm dummy load and keyed at a rate of 12 dot cycles per second.
- b. The keyed waveshape shall be observed directly on a wide band oscilloscope and in addition, the signal shall be inspected for "chirping", key clicks and other irregular wave shapes by tuning a communication receiver to the carrier frequency.

Requirement:

The envelope of the keyed wave shall possess rounded corners on the leading and trailing edges and shall have no sharp peaks or abrupt transients. The observed signal shall be free from key clicks and "chirping" over the entire frequency range of the equipment.

3.3.2.2. Keying at High Speeds

Method of Test:

- a. The transmitter shall be loaded into a 300 ohm dummy antenna and keyed at a rate of 150 dot-cycles per second.
- b. The conditions of Section 3.3.2.1. (b) shall apply.

Requirement:

The requirements of Section 3.3.2.1. shall be met.

3.3.3. Crystal Input Capacity

Method of Test:

- a. The transmitter shall be tuned into a 300 ohm load at the test frequencies of Section 3.1.
- b. The transmitter frequency shall be measured using a secondary frequency standard.
- c. The crystal shall be removed from the transmitter and inserted in the crystal oscillator correlation circuit of Section 1.3.7.
- d. The input capacity shall be varied to produce the same frequency as determined in step (b).

Requirement:

The input capacity shall not be less than 30 mmfd nor more than 34 mmfd.

3.3.4. Crystal Current

Method of Test:

- a. Crystal current shall be measured by inserting an R.F. milliammeter in series connection with the crystal. Leads are to be short as possible.

Requirement:

The crystal current shall not exceed 30 milliamperes R.F. under any conditions of tuning or operation over the entire range of the equipment.

3.3.5. Interference

3.3.5.1. Key Click Radiation

Method of Test:

- a. The transmitter shall be set up for operation at the frequency test points defined by Section 3.1. and loaded into a 300 ohm dummy load. The transmitter shall be keyed at 12 dot-cycles per second.
- b. The Stoddart Field Intensity meters shall be operated at a distance of one foot from the RT-21 and tuned throughout the frequency range of 150 kc to 220 mc. The spectrum shall be visibly and audibly monitored for the presence of key-click radiation.

Requirement:

Key-click radiation shall not exceed 600 microvolts at one foot distance.

3.3.5.1.1. Key Click Radiation

- a. The transmitter shall be set up for operation at the frequency test points noted by Section 3.1. and loaded into a 300 ohm dummy load. The transmitter shall be keyed at a 150 dot-cycle rate.
- b. The Stoddart Field Intensity meters shall be operated at a distance of one foot from the RT-21 and tuned throughout the frequency range of 150 kc to 220 mc. The spectrum shall be visibly and audibly monitored for the presence of key-click radiation.

Requirement:

Key-click radiation shall not exceed 600 microvolts of one foot distance.

3.3.5.2. Harmonic Radiation

Method of Test:

- a. The transmitter shall be set up for operation at the frequency test points stated in Section 3.1. and loaded into a 300 ohm dummy antenna.
- b. The transmitter shall be keyed in a "key-down" condition, radiating a steady carrier devoid of modulation at a power level of not less than 10 watts of R.F. energy.

- c. The vertical antenna of the Field Intensity meter shall be extended one foot. The dummy antenna of the transmitter and the vertical antenna of the meter shall be placed three feet apart.
- d. The intensity of the fundamental transmitter signal shall be measured with the Field Intensity meter.
- e. Without disturbing any settings or adjustments, other than the calibrated attenuator of the meter, the intensity of the second, third, and fourth harmonics of the fundamental carrier shall be measured.

Requirements:

- a. The second harmonic shall be 35 decibels or more below the level of the fundamental.
- b. The third harmonic shall be 45 decibels or more below the level of the fundamental.
- c. The fourth and higher order harmonics shall be 80 decibels or more below the level of the fundamental.

3.3.5.3. Radiation and Conducted Interference

Method of Test:

- a. Method of test used shall conform with MIL-I-16910A (SHIPS) insofar as is practicable. Measurements of radiated and conducted interference shall be made using the rod or loop antenna supplied with the particular test instrument employed.
- b. This test shall cover the frequency range of 15 kc to 220 mc.

Requirements:

The requirements and limitations defined in the MIL-I-16910A (SHIPS) Specification shall apply.

3.3.5.3.1. Spurious Radiation

Removal of Crystal and VFO.

- a. The crystal and VFO shall be disconnected from the transmitter.
- b. The method of test shall be identical to that of Section 3.3.5.3.

Requirement:

There shall be no generation of R.F. power with the crystal and VFO removed.

3.3.5.3.2. DC-to-DC Converter Radiation

Method of Test:

- a. Identical to that required by Section 3.3.5.2. above, except that the spectrum shall be examined for DC-to-DC converter radiation in the frequency range of 15 kc to 220 mc, and the RT-21 shall be keyed at 12 dot cycles.

Requirement:

No radiation shall be generated by the DC-to-DC converter in the frequency range of 15 kc to 220 mc.